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Updated taxonomic keys for European Hippoboscidae (Diptera), and expansion in Central Europe of the bird louse fly *Ornithomya comosa* (Austen, 1930) with the first record from Slovakia

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Abstract

The available keys for European Hippoboscidae are outdated and do not cover all species currently known from Europe. Therefore, identification keys to the eleven genera and 31 species of the European hippoboscids are provided here. *Ornithomya comosa* (Austen, 1930) (Diptera: Hippoboscidae) is recorded for the first time from the territory of Slovakia based on one female found on a sand martin, *Riparia riparia* (Linnaeus, 1758). The list of keds and louse flies recorded from the territory of Slovakia is increased to 20 species. New host records for Slovakia are presented.

Keywords

Birds, hippoboscid, new host records, new record, parasite, Slovakia, taxonomic keys

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Introduction

Keds and louse flies (Diptera: Hippoboscidae) are among the most fascinating as well as disregarded group of blood-feeding ectoparasites, and they thrive on many animal species (Bezerra-Santos and Otranto 2020). This family is included in the superfamily Hippoboscoidea, along with the families Glossinidae (tse-tse flies), Streblidae, and Nycteribiidae (bat flies) (Petersen et al. 2007; Reeves and Lloyd 2019). Hippoboscidae are divided into the subfamilies Lipopteninae (tribe Lipoptenini parasitising exclusively mammals), Ornithomyinae (tribes Olfersiini and Ornithomyini composed of species that mostly parasitise birds) and Hippoboscinae (tribe Hippoboscini with all species in Europe affecting mammals) (Reeves and Lloyd 2019). Phylogenetic studies have indicated a monophyly among Hippoboscoidea members and that the ancestor of this superfamily was a free-living insect feeding on mammal blood (Nirmala et al. 2001; Dittmar et al. 2006; Petersen et al. 2007).

Worldwide, more than 213 hippoboscid species are known (e.g., Maa 1963; Dick 2006; Rahola et al. 2011), and 31 species of Hippoboscidae have been described from Europe (Pape et al. 2015; Nartshuk et al. 2019a; Oboňa et al. 2019b).

Ornithomya comosa (Austen, 1930) (Figs 1, 2), the most recent species found in Europe (see Nartshuk et al. 2019a) and originally described from India (Pusa, Bihar), was first collected from a grey-throated martin, *Riparia chinensis* (J. E. Gray, 1830) (Austen 1930). The host overview is presented in Table 1. According to Maa (1969a, b, 1977), *O. comosa* is distributed in India, Nepal (on *R. chinensis*; Maa (1969a) used the name *Riparia paludicola chinensis*), and Thailand and Malaysia (on a barn swallow, *Hirundo rustica* Linnaeus, 1758).

Subsequently, Doszhanov (1970, 2003) recorded this species from Kazakhstan, Kyrgyzstan and West Siberia of Russia (Novosibirsk), mostly from the host *Riparia riparia* (Linnaeus, 1758), rarely from *H. rustica* and *Delichon urbicum* (Linnaeus, 1758), and also from the Eurasian scops owl, *Otus scops* (Linnaeus, 1758) of the Strigiformes. Mogi (2014) reported this species from Japan (Honshu, Kyushu and Ryukyu islands on *R. riparia* and *H. rustica* hosts). Most recently, Nartshuk et al. (2019a) recorded *O. comosa* for the first time in Europe from western Russia (Kaliningrad Province, hosts *H. rustica* and *D. urbicum*). Further Russian records are from *Cecropis daurica* (Laxmann, 1769) from Primorskii krai in the Far East (Nartshuk et al. 2019b) and from *Riparia diluta* (Sharpe & Wyatt, 1893) from Tomsk in west Siberia (Matyukhin

Table 1. The overview of hosts of *Ornithomya comosa* (Austen, 1930).

Host species	Countries	References
Cecropis daurica	Russia	Nartshuk et al. (2019b)
Delichon urbicum	Kazakhstan, Kyrgyzstan, Russia	Doszhanov (1970); Nartshuk et al. (2019a)
Hirundo rustica	Japan, Kazakhstan, Kyrgyzstan, Malaysia, Russia, Thailand,	Maa (1969a); Doszhanov (1970); Mogi (2014); Nartshuk et al. (2019a)
Otus scops	Russia	Doszhanov (2003)
Riparia diluta	Russia	Matyukhin and Gashkov (2020)
Riparia chinensis	India, Nepal	Austen (1930); Maa (1969a)
Riparia riparia	Japan, Kazakhstan, Kyrgyzstan, Russia	Doszhanov (1970); Mogi (2014)

and Gashkov 2020). In this study *O. comosa* is recorded for the first time from Slovakia, demonstrating its further expansion in Central Europe.

A series of new records of louse flies and keds from Slovakia with several new host records is appended to supplement the recent review by Oboňa et al. (2019b). Because the available taxonomic keys for European Hippoboscidae are outdated, we present updated keys covering all species currently known from Europe.

Materials and methods

The key for European genera of Hippoboscidae follows the previous descriptions by Bequaert (1954), Theodor and Oldroyd (1964), and Hutson (1984). Keys for species of European Hippoboscidae follow Falcoz (1926), Povolný and Rosický (1955), Theodor and Oldroyd (1964), Maa (1966, 1969c), Hutson (1981, 1984), Ducháč and Bádr (1998), Farafonova (2001), Petersen et al. (2007), Iwasa and Choi (2013), Nartshuk et al. (2019b), and Salvetti et al. (2020).

In addition, new louse fly specimens from Slovakia were collected by hand on birds caught in mist nets, or keds by hand from humans. The majority of the samples come from the ornithological station "Vtáčí raj – Šalgovské rybníky" (Bird's Paradise

Figure 1. *Ornithomya comosa*, imago, dorsal view (left wing removed).

Figure 2. *Ornithomya comosa*, wing.

– Šalgov ponds) near the village Uzovský Šalgov (49°05'34.8"N, 21°04'00.4"E, 366 m a.s.l.). The birds were mist-netted in the standardised method (for more information, see Olekšák et al. 2007). Other samples, especially from humans, represent random and non-targeted sampling.

The collected hippoboscids were placed in microvials with 96% ethanol and subsequently identified in the laboratory using determination keys by Povolný and Rosický (1955) and Theodor and Oldroyd (1964). The focus on the local primary hosts follows Oboňa et al. (2019a, b, 2021). The newly recorded species *O. comosa* (Austen, 1930) was identified by Nartshuk et al. (2019b) using a key modified according Farafonova (2001). The material is deposited in the collection of the Laboratory and Museum of Evolutionary Ecology, Department of Ecology, University of Prešov (**LMEE PO**). The terminology follows Cumming and Wood (2017).

Results

Key for European genera of Hippoboscidae (updated)

1 Wings fully developed and functional (Figs 3–11) **2**

– Wings reduced, with strong veins (Figs 12–16) or absent (either by reduction or loss) **9**

2 Tarsal claws simple (Fig. 17), but with a pale basal lobe; humeral callus weak (Figs 21–24), postpronotum rounded, not produced anteriorly as conical lobes **3**

– Tarsal claw bifid and with a pale basal lobe (Fig. 18); humeral callus strong, postpronotum rounded, pair of conical lobes on either side of head (Figs 26–28), on birds..... **5**

3 Wing with one or two cross-veins; R_{4+5} well separated from C until apex; on mammals (Figs 4, 5) **4**

– Wings with three cross-veins enclosing cells posterior to radial veins; apical 1/2 of vein R_{4+5} running very close to C (Fig. 3); on birds..... ***Ornithoica***

4 Wing clear and hyaline, with only one cross-vein (Fig. 4); head broader than long; thorax markedly flattened (Figs 21–25); on mammals..... ***Lipoptena***

– Wing distinctly crenulated and tinted, with two cross-veins (Fig. 5); head not broader than long; thorax not so markedly flattened; on mammals..... ***Hippobosca***

5 Wing with three cross-veins posterior to radial veins (Figs 6, 7); scutellum with four or more strong marginal setae (Figs 32–37) **6**

– Wing with one or two cross-veins posterior to radius (Figs 8–11); scutellum at most with two strong marginal setae (Figs 31, 38) **7**

6 Vein R_{2+3} with apical 3/5 fused with C; wing membrane entirely bare (Fig. 6)..... ***Ornithophila***

– Vein R_{2+3} well separated from C except at apex; wing membrane usually with microtrichia (Fig. 7)..... ***Ornithomya***

7 Wing with only one cross-vein (Fig. 8) ..... ***Pseudolynchia***

– Wing with two cross-veins (Figs 9–11) **8**

8 Scutellum with two strong setae (Fig. 19) ..... ***Icosta***

– Scutellum with setulae (Fig. 31)..... ***Olfersia***

9 Wing long and narrow, at least 6 × as long as wide and twice as long as head and thorax (Fig. 12); female abdomen with strong spiniform setae in posterolateral area; male abdomen without spiniform setae..... ***Stenepteryx***

– Wing short and broad, at most 3 × as long as wide and ~ 1.5 × as long as head and thorax (Figs 13–16); tip of wing usually attenuated, C reaching to about 0.75 length of anterior wing margin; female abdomen only with short fine setae in posterolateral area..... ***Crataerina***

10 Wings either reduced to a veinless knob or broken off; haltere absent..... ***Melophagus***

– Wings absent, leaving a broad flat veined stump; haltere present.... ***Lipoptena***

Keys to species of European genera of Hippoboscidae (updated)

The genus *Crataerina* von Olfers, 1816

1 Wing shorter than hind femur; wing tip broadly rounded (Fig. 13)..... ***Crataerina obtusipennis*** **Austen, 1926**

– Wing longer than hind femur **2**

2 Wing more than twice as long as hind femur (Fig. 14); male abdomen with tergites 3 and 4 one-third as wide as abdomen and tergite 5 nearly as wide as abdomen; female abdomen with long and thick setae on posterior margin and with group of fine and long setae ventral to genital opening..... ***Crataerina melbae*** **(Rondani, 1879)**

– Wing < 2 × as long as hind femur; male abdominal tergites small or absent; all setae on posterior margin of female abdomen short and uniform in length..... **3**

3 Wing length 2 × as long as hind femur, extended beyond posterior end of abdomen; distal 1/2 of trailing edge of wing strongly concave (Fig. 15) .... ***Crataerina acutipennis*** **Austen, 1926**

– Wing length 1.3–1.5 × as long as hind femur, not extended beyond posterior end of abdomen; distal 1/2 of trailing edge of wing not strongly concave (Fig. 16) ..... ***Crataerina pallida*** **(Olivier in Latreille, 1811)**

Host-parasite associations: Aves (Apodiformes, Passeriformes).

The genus *Hippobosca* Linnaeus, 1758

1 Vein R_{2+3} meets vein C at same place as R_1, shorter than distal section of R_{4+5} (measured from transverse vein r-m); front edge of thorax, with a transverse row of short thick setae; scutellum almost rectangular, with 2 dark and 3 light spots; wing length 7.0–8.0 mm .... ***Hippobosca variegata*** **Megerle, 1803**

– Vein R_{2+3} end into vein C clearly separated from R_1, length is approximately equal to distal section of vein R_{4+5}; thorax without mentioned setae and characters; wing length shorter than 7.0–8.0 mm **2**

2 Dark brown specimens; veins of wings dark pigmented; scutellum white in middle, dark on sides; wing length 6.0–8.5 mm (Fig. 5) .... ***Hippobosca equina*** **Linnaeus, 1758**

– Pale specimens; veins of wings light, only transverse veins and sections of longitudinal veins adjoining them are completely or partially dark; scutellum almost entirely white, sometimes with dark edge; wing length 5.0–6.0 mm ..... ***Hippobosca longipennis*** **Fabricius, 1805**

Host-parasite associations: Aves (Accipitriformes), Mammalia (Carnivora, Cetartiodactyla, Perissodactyla).

The genus *Icosta* Speiser, 1905

1 Large dark specimens; wing length 5.0–6.0 mm **2**

– Small pale specimens; wing length 3.5–4.0 mm **3**

2 Venter of hind femur bare; palp length more than twice width; microtrichia covering most of wing, but apical 1/2 of cell Cu+1A and entire 2A bare (Fig. 10); prescutum with setae reaching mesonotal suture; pale yellowish specimens; abdomen without tergite 3 (Fig. 39)..... ..... ***Icosta minor*** **(Bigot in Thomson, 1858)**

3 Venter of hind femur densely setose except near base; length of palp ~ 1.5 × width; wing with microtrichia covering most of its surface, including anterior 1/3 of cell 2A (Fig. 9); prescutum with short setae in several rows not reaching mesonotal suture, smaller and disordered short postalar setae in several rows

(Fig. 19); dark specimens; abdomen with distinct tergite 3 (Fig. 40) .... ***Icosta ardeae*** **(Macquart, 1835)**

– Enigmatic species, so far known from a single specimen; prescutum with one row of fine longer setae that reach mesonotal suture, setae in one row (Fig. 20) ..... ***Icosta massonati*** **(Falcoz, 1926)**

Host-parasite associations: Aves (Passeriformes, Pelecaniformes).

The genus *Lipoptena* Nitsch, 1818

1 Wing length 6.0 mm **2**

– Wing length 4.0 mm or less **3**

2 Body length 5.0–6.0 mm; scutellum with 6–8 setae; thorax mostly with 30–35 setae on each side, 9 postalar setae on each side (Fig. 21) .... ***Lipoptena cervi*** **(Linnaeus, 1758)**

– Body length 4.5–5.5 mm; scutellum with 8–10 setae; thorax mostly with 50–60 setae on each side, 6 postalar setae on each side (Fig. 22) .... ***Lipoptena couturieri*** **Séguy, 1935**

3 Wing length 4.0 mm; body length 2.8–3.2 mm; scutellum with 4–6 setae; thorax mostly with 8–12 strong setae on each side, 4 postalar setae on each side (Fig. 23) ..... ***Lipoptena fortisetosa*** **Maa, 1965**

– Wing length < 4.0 mm; scutellum with 6 setae; thorax mostly with 25 or more setae on each side, 3 or 4 postalar setae on each side **4**

4 Wing length 3.0–3.2 mm; body length 3.0–3.75 mm; body pale; thorax mostly with 30–35 setae on each side (Fig. 24) ..... ***Lipoptena capreoli*** **Rondani, 1878**

– Wing length < 3.0 mm body length 2.3–2.6 mm; body extremely dark; thorax mostly with 25–30 soft setae on each side (Fig. 25) .... ***Lipoptena arianae*** **Maa, 1969**

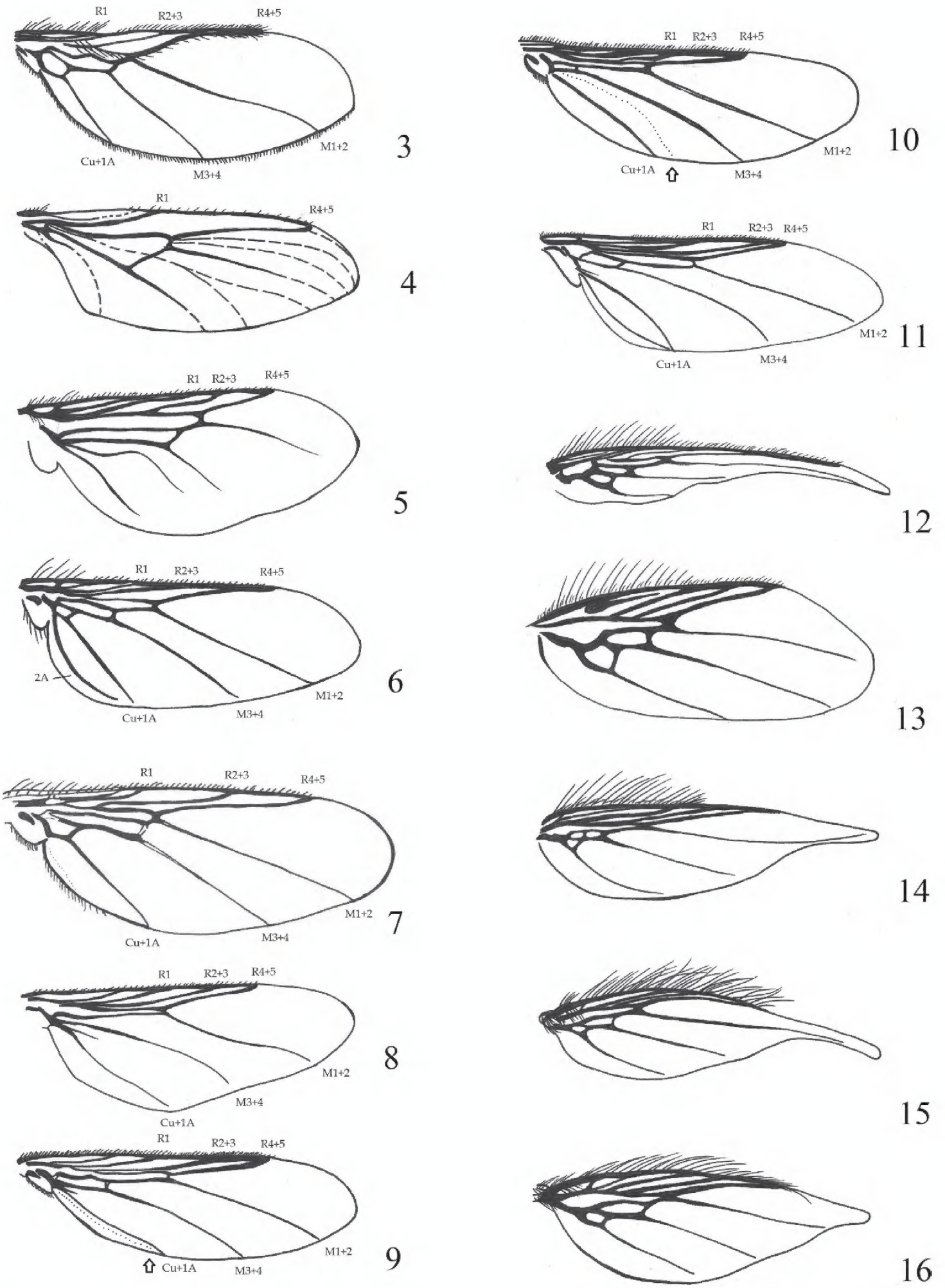
Host-parasite associations: Mammalia (Cetartiodactyla, Carnivora).

The genus *Melophagus* Latreille, 1802

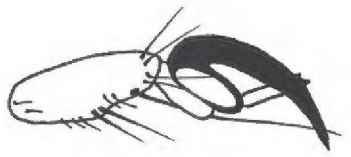
1 Palps almost as long as head, in rest position completely covering proboscis (Fig. 29); parafrontalia almost touching in middle, mediovertex reduced; parafrontalia covered with numerous setae; tergal plates completely absent in male, in females only remnants of tergal plate 7 .... ***Melophagus ovinus*** **(Linnaeus, 1758)**

– Palps shorter than head, ~ 1/3 of head length, proboscis always protruding (Fig. 30); parafrontalia with few setae on inner margin; in males tergal plate 6 present, in females plates 6 and 7 present ..... ***Melophagus rupicaprinus*** **Rondani, 1879**

Host-parasite associations: Mammalia (Carnivora, Cetartiodactyla, Perissodactyla).



Figures 3–16. 3 *Ornithoica turdi*, wing **4** *Lipoptena cervi*, wing **5** *Hippobosca equina*, wing **6** *Ornithophila metallica*, wing **7** *Ornithomya avicularia*, wing **8** *Pseudolynchia canariensis*, wing **9** *Icosta ardeae*, wing (with the border of microtrichia) **10** *Icosta minor*, wing (with the border of microtrichia) **11** *Olfersia spinifera*, wing **12** *Stenepteryx hirundinis*, wing **13** *Crataerina obtusipennis*, wing **14** *Crataerina melbae*, wing **15** *Crataerina acutipennis*, wing **16** *Crataerina pallida*, wing.



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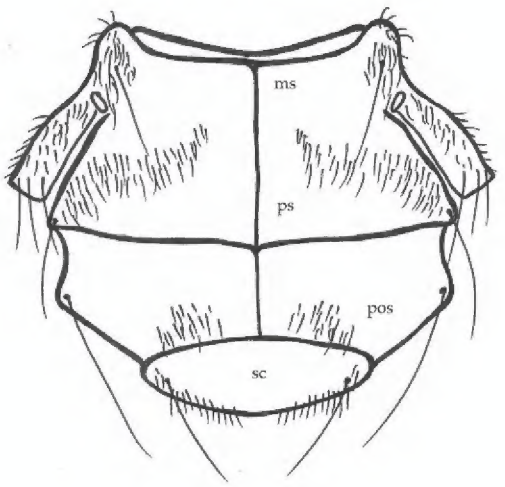

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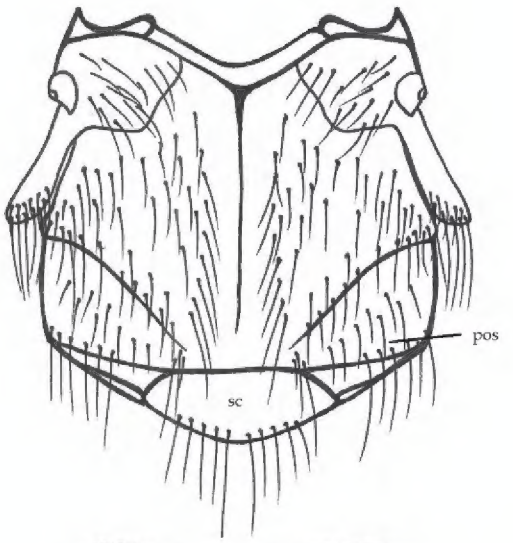

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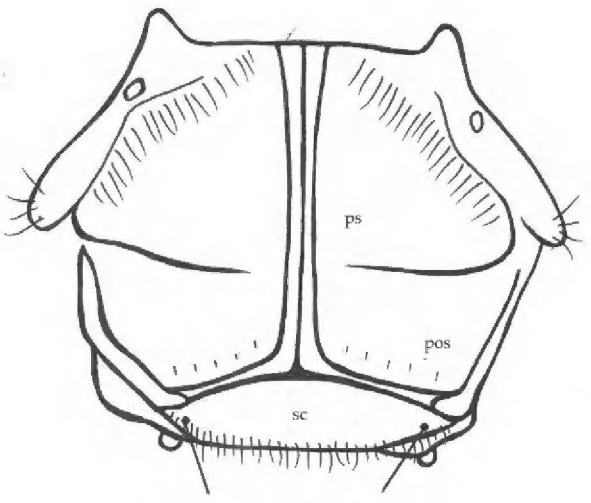

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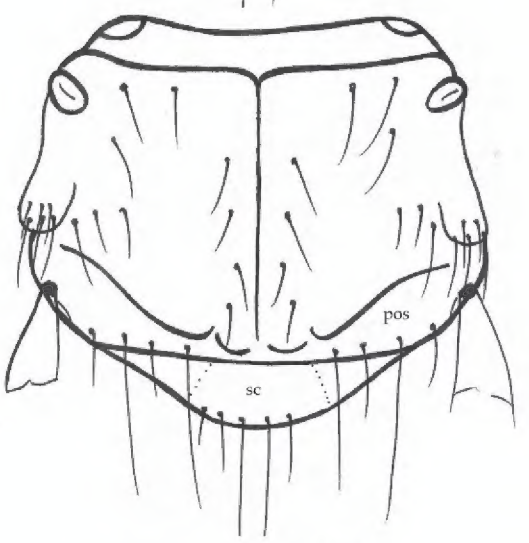

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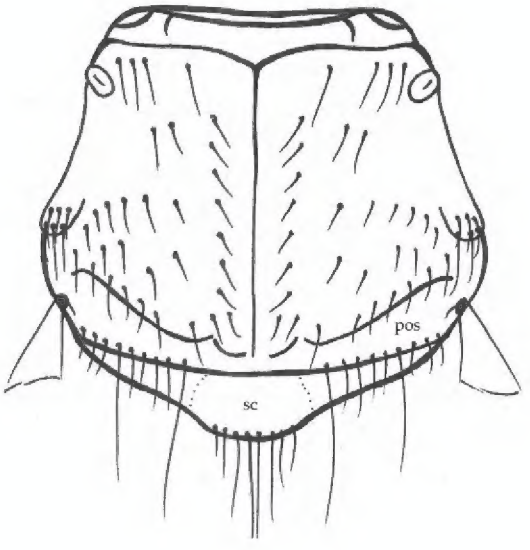

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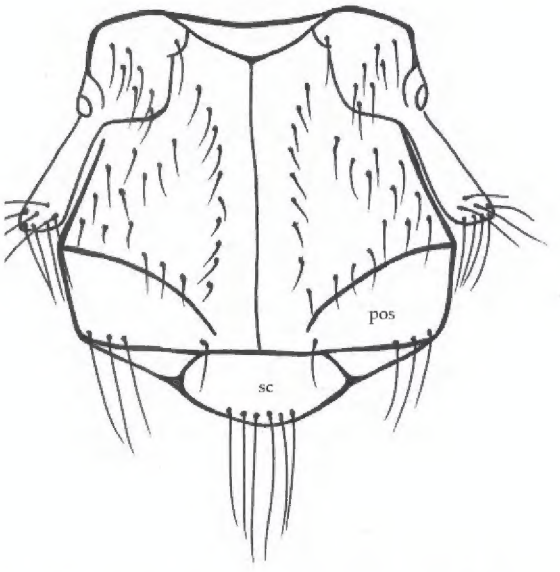

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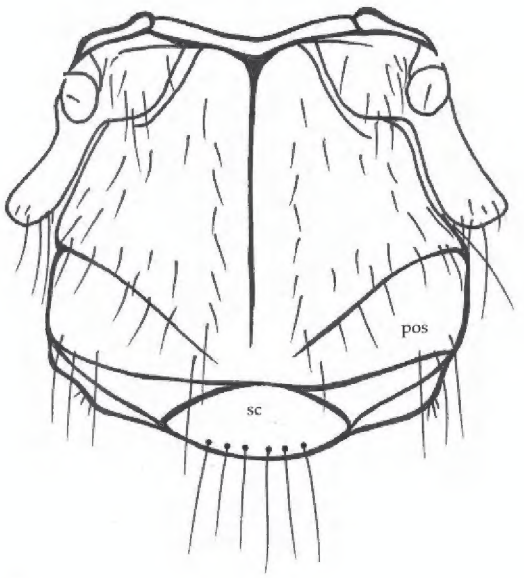
Figures 17–24. 17 *Lipoptena cervi*, tarsal claws **18** *Ornithomya avicularia*, tarsal claws **19** *Icosta ardeae*, thorax **20** *Icosta massonati*, thorax **21** *Lipoptena cervi*, thorax **22** *Lipoptena couturieri*, thorax **23** *Lipoptena fortisetosa*, thorax **24** *Lipoptena capreoli*, thorax. Abbreviations: ms – mesonotal suture, pos – postalar setae, ps – prescutum, sc – scutellum.



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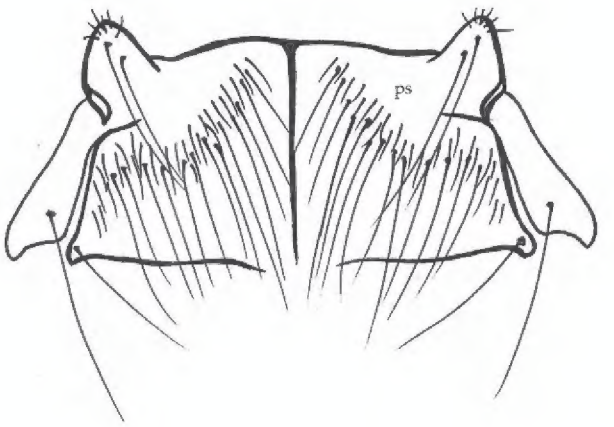

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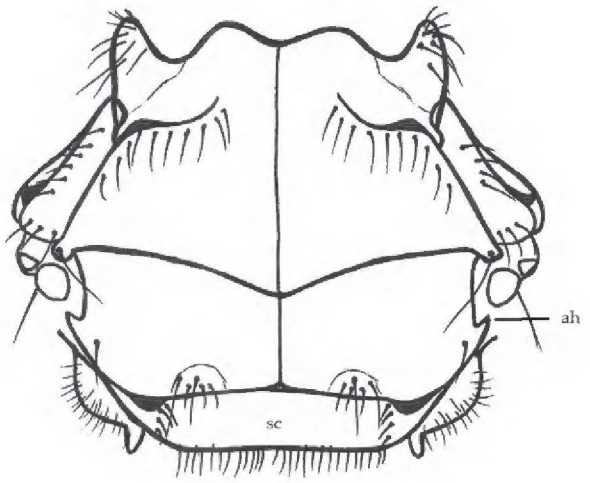

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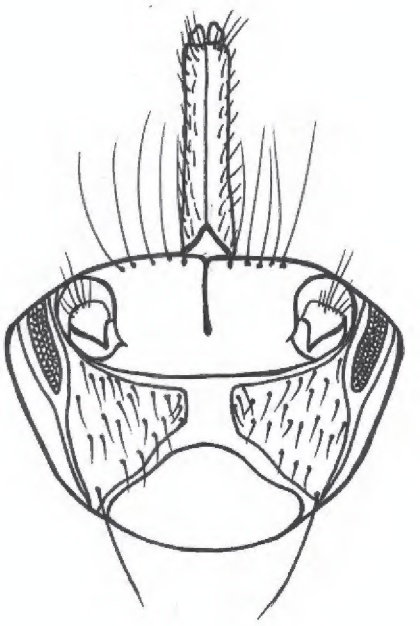

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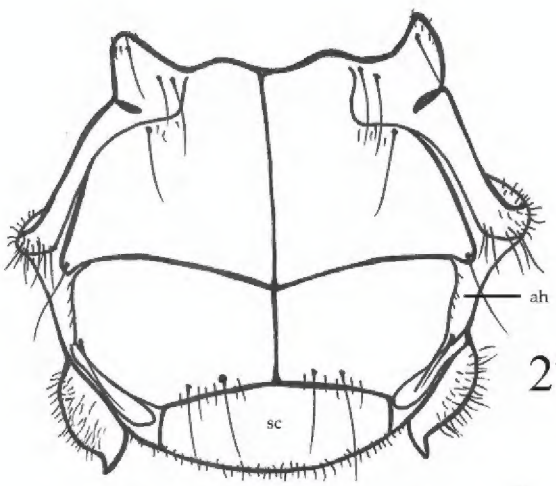

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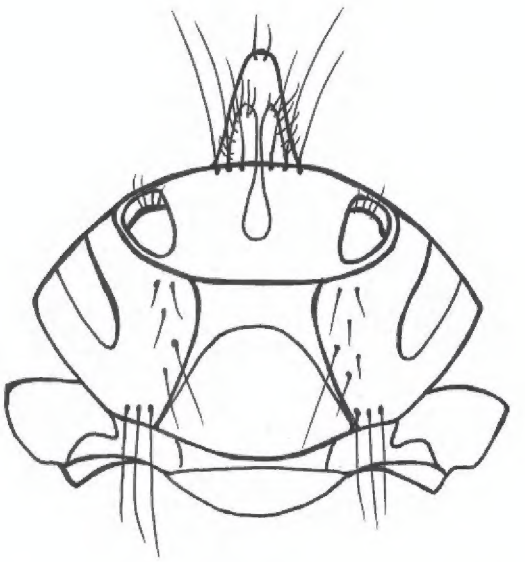

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Figure 25–30. 25 *Lipoptena arianae*, thorax **26** *Olfersia spinifera*, thorax **27** *Olfersia fumipennis*, thorax **28** *Pseudolynchia canariensis*, frontal part of thorax **29** *Melophagus ovinus*, head with palps **30** *Melophagus rupicaprinus*, head with palps. Abbreviations: ah – alar horns, pos – postalar setae, ps – prescutum, sc – scutellum.

The genus *Olfersia* Wiedemann, 1830

1 Head on posterior margin with 3 distinct protrusions and deep indentations between postvertex and posterior orbit; postvertex protrudes noticeably

backwards over posterior orbites; tip of alar horns directed obliquely forward (Fig. 26); section of C between Sc and R_1 is shorter than section between R_1 and $R_{2\text{-}3}$. First basal cell is ca. as long as section of R_{4+5} distal to transverse vein r-m (Fig. 11); female pygidium separate and finger-shaped .... ***Olfersia spinifera*** **(Leach, 1817)**

– Head protruding only a little over posterior orbit; tip of alar horns blunt and serrated (Fig. 27); sections of C between Sc and R_1 longer than section between R_1 and $R_{2+3.}$ First basal cell is significantly shorter than section of R_{4+5} distal to transverse vein r-m; female pygidium short and fused..... ..... ***Olfersia fumipennis*** **(Sahlberg, 1886)**

Host-parasite associations: Aves (Accipitriformes, Gaviiformes, Charadriiformes, Pelecaniformes, Suliformes).

The genus Ornithoica *Rondani*, 1878 – one species only

Ornithoica turdi **(Olivier in Latreille, 1812)**
Figs 3, 32

Host-parasite associations: Aves (Passeriformes).

The genus *Ornithomya* Latreille, 1802

1 C sector between R_1 and R_{2+3} not longer than sector between R_{2+3} and R_{4+5} ...**2**

– C sector between R_1 and R_{2+3} longer than between R_{2+3} and R_{4+5}.....**3**

2 Brown spots on ventral side of head do not reach jugular setae; scutellum with 4 setae (Fig. 33); wing in hind part with 4 longitudinal stripes of microtrichia; adult 1.9–2.5 mm .... ***Ornithomya fringillina*** **Curtis, 1836**

– Triangular brown spots on ventral side of head are sharp (Fig. 41), narrowed and reach jugular setae, which are situated on sides of occipital foramen; scutellum usually with 6 or more setae (Fig. 34); wing in hind part with 3 longitudinal stripes of microtrichia; adult 2.1–2.6 mm .... ***Ornithomya chloropus*** **Bergroth, 1901**

3 Wing dark and all surface evenly covered by microtrichia; scutellum with 10–12 setae (Fig. 35); all body covered by setae; adult 2.0–2.5 mm..... ..... ***Ornithomya comosa*** **(Austen, 1930)**

– Surface of wing covered by microtrichia no more than 2/3, base of wing without of microtrichia.....**4**

4 Wing with microtrichia only on apex and in cell m_1; scutellum with 8 setae (Fig. 36); abdomen on apex with numerous long setae; adult 3.0–3.5 mm ... . ***Ornithomya avicularia*** **(Linnaeus, 1758)**

– Microtrichia covered nearly all wing except base or only cells r_3 and $m_{2,}$ long setae absent on apex of abdomen **5**

5 Wing dark with intensive microtrichia; thorax with 16–18 mesopleural setae on each side; scutellum with 6 setae (Fig. 37); abdomen similar as in following species; vibrissal spines almost missing..... ***Ornithomya biloba*** **Dufour, 1827**

– Wing light with extensive microtrichia, thorax with 6–10 mesopleural setae on each side; scutellum with 4 (6) setae; abdomen (Figs 43, 44); vibrissal spines present (Fig. 42) ..... ***Ornithomya rupes*** **Hutson, 1981**

Host-parasite associations: Aves (Accipitriformes, Anseriformes, Falconiformes, Passeriformes, Pelecaniformes, Strigiformes), Mammalia (Primates).

The genus *Ornithophila* Rondani, 1879

1 4.0–5.0 mm; scutellum dark, except for a narrow, light stripe at base; male tergal plates 3 and 4 as wide as scutellum..... ***Ornithophila metallica*** **(Schiner, 1864)**

– 5.0–7.0 mm; scutellum with a broad yellow band at base and a yellow triangle at apex; male tergal plates 3 and 4 as wide as a little more than 1/2 width of scutellum ..... ***Ornithophila gestroi*** **(Rondani, 1878)**

Host-parasite associations: Aves (Passeriformes).

The genus *Pseudolynchia* Bequaert, 1926

1 Hind scutellar margin in dorsal view straight or nearly straight (Fig. 38); interantennal area of frons as wide as or rarely slightly narrower than its distance to eye; prescutum with 20–30 long pale fine setae and before which with 2 or 3 series of shorter ones (Fig. 28); mid tarsus with group of peg-like modified spines under segment 1 at base..... ..... ***Pseudolynchia canariensis*** **(Macquart in Webb & Berthelot, 1839)**

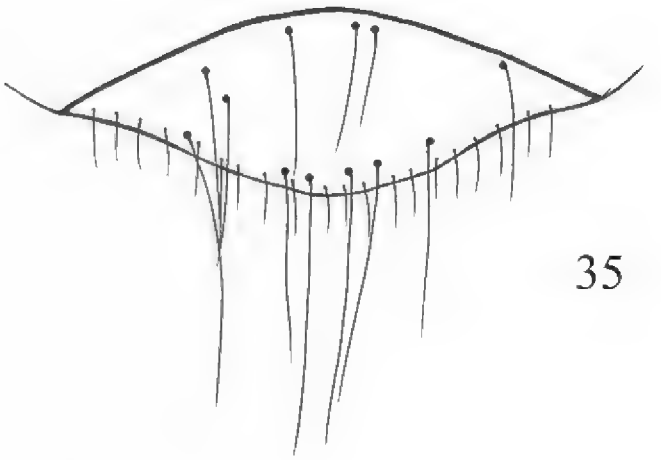
– Hind scutellar margin in dorsal view distinctly curved; interantennal area of frons always much narrower than its distance to eye; prescutum with 12–18 long, fairly robust and generally black setae and before which, with 1 or 2 series of shorter ones; mid tarsus with only pointed setae under segment 1 at base..... ***Pseudolynchia garzettae*** **(Rondani, 1879)**

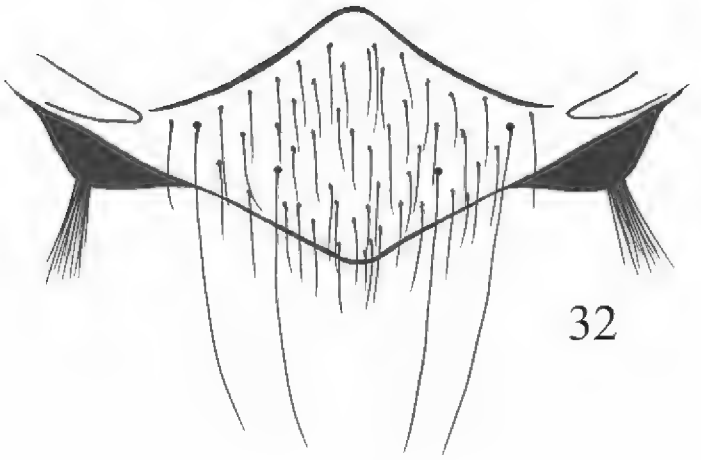
Host-parasite associations: Aves (Accipitriformes).

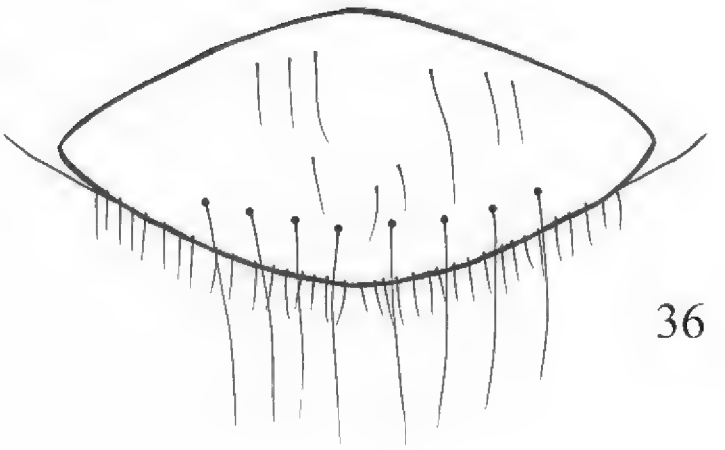
The genus *Stenepteryx* Leach, 1817 – one species only

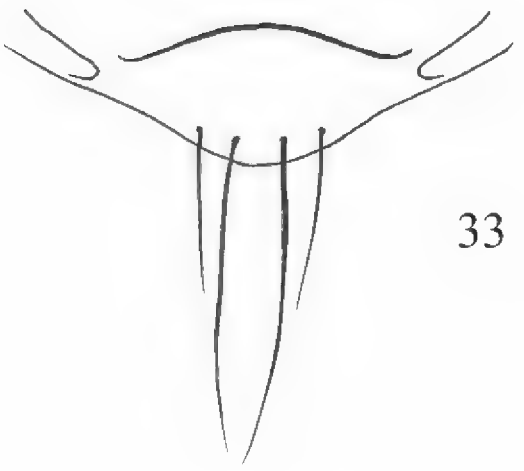
Stenepteryx hirundinis **(Linnaeus, 1758)**
Fig. 12

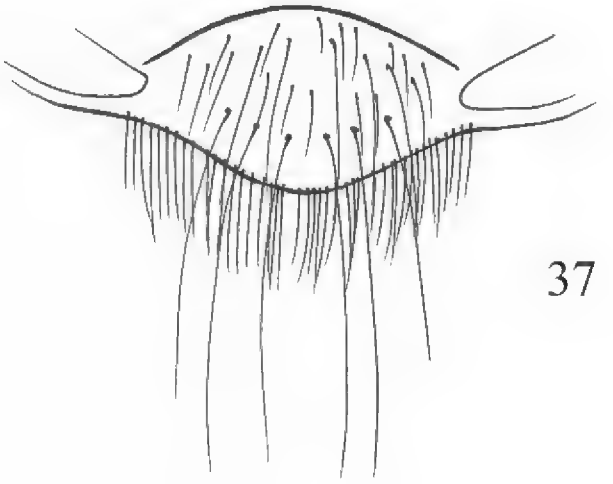
Host-parasite associations: Aves (Passeriformes: Hirundinidae).

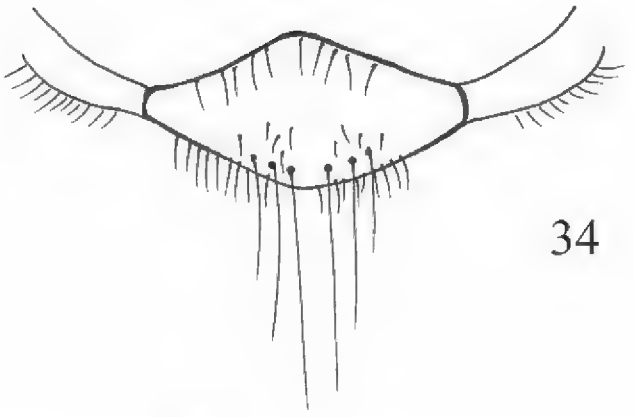


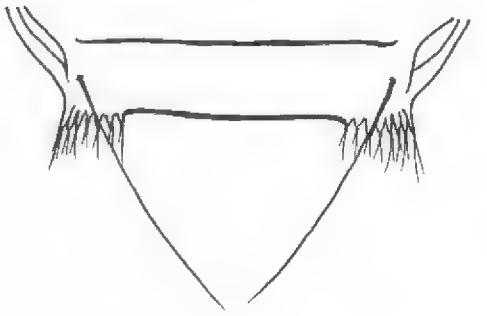












Figures 31–38. 31 *Olfersia fumipennis*, scutellum **32** *Ornithoica turdi*, scutellum **33** *Ornithomya fringillina*, scutellum **34** *Ornithomya chloropus*, scutellum **35** *Ornithomya comosa*, scutellum **36** *Ornithomya avicularia*, scutellum **37** *Ornithomya biloba*, scutellum **38** *Pseudolynchia canariensis*, scutellum.

Faunistics

New record for Slovakia

Ornithomya comosa (Austen, 1930)

Material examined. Uzovský Šalgov, around a pond, 49°05'34.8"N, 21°04'00.4"E, 366 m a.s.l., 14.7.2021, 1 ♀ (Fig. 1), from *R. riparia* [ring number – U69400] (LMEE PO).

Note. This is a dark louse fly (Fig. 1); all of its surfaces are unusually dark, wings are covered by microtrichia (Fig. 2). Scutellum with 10–12 long setae (6 subapical and 6 subbasal – see Fig. 35), and its body is covered by hairs.

Distribution. India (Pusa, Bihar), Japan (Honshu, Kyushu and Ryukyu islands), Kazakhstan, Kyrgyzstan, Malaysia, Nepal, Russia: western European Russia (Kaliningrad Prov.), West Siberia (Novosibirsk, Tomsk), Far East (Primorskii krai), and Thailand (Austen 1930; Maa 1969a, b, 1977; Doszhanov 1970, 2003; Mogi 2014; Nartshuk et al. 2019a, b, 2020; Matyukhin and Gashkov 2020).

Known hosts. see also in Table 1; Passeriformes: Hirundinidae (*C. daurica*, *D. urbicum*, *H. rustica*, *R. chinensis*, *R. diluta*, *R. riparia*) and Strigiformes: Strigidae (*O. scops*) (Austen 1930; Maa 1969a, b, 1977; Doszhanov 1970, 2003; Mogi 2014; Nartshuk et al. 2019a, b, 2020; Matyukhin and Gashkov 2020).

Additional records from Slovakia

Hippobosca equina Linnaeus, 1758

Material examined. Diviacka Nová Ves, margin of a *Quercus* forest, 48°45'12.3"N, 18°29'15.0"E, 320 m a.s.l., 1 ♀, 9.8.2021, from a human.

Note. Records from humans are accidental associations and the species do not complete development on this host.

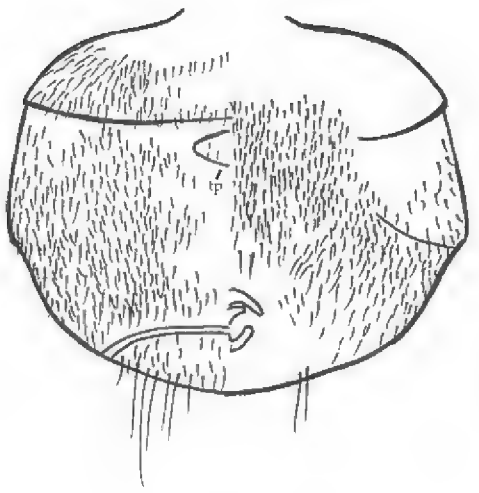
Lipoptena cervi (Linnaeus, 1758)

Material examined. Lažany, 49°2'18.111"N, 21°5'22.029"E, 380 m a.s.l., 10.6.2021, 1 ♀, from a human.

Note. Similar to *H. equina*.

Lipoptena fortisetosa Maa, 1965

Material examined. Lažany, 49°2'18.111"N, 21°5'22.029"E, 380 m a.s.l., 10.6.2021, 2 ♀, from a human; Sabinov Bird Ringing Station, 49°06'02.7"N, 21°04'26.8"E, 370 m a.s.l., 5.7.2021, 1 ♀, from *Parus major* Linnaeus, 1758 [P132706], the same,



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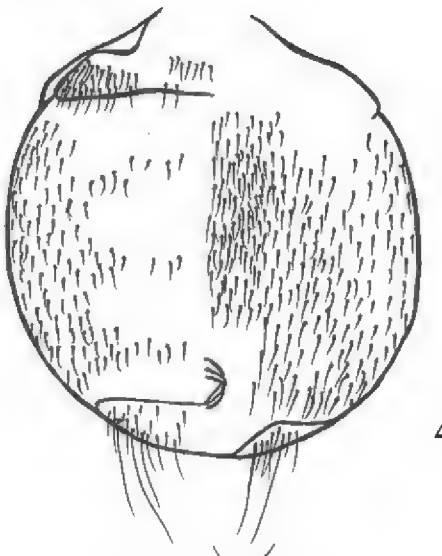

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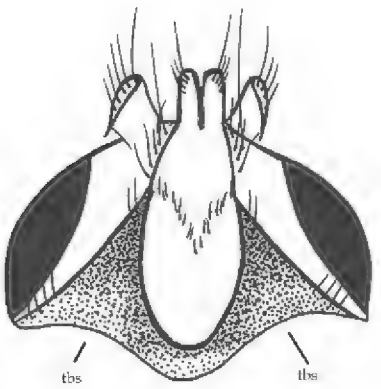

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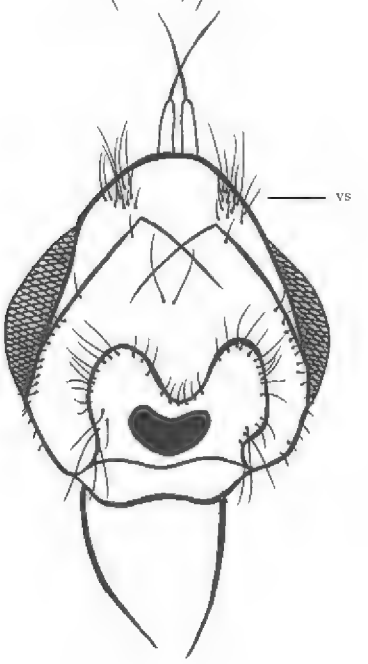

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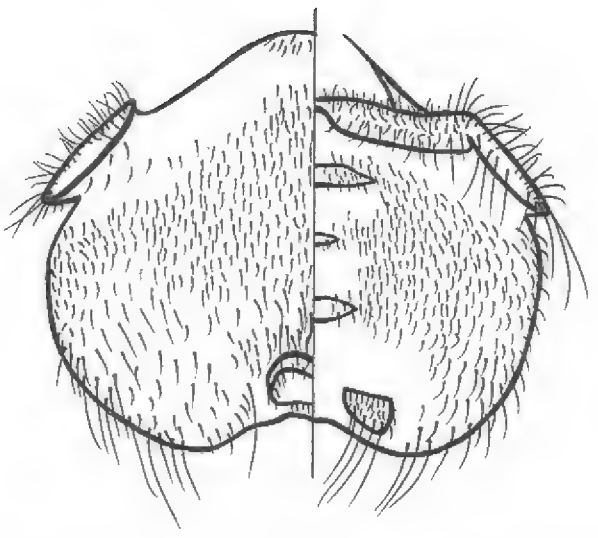

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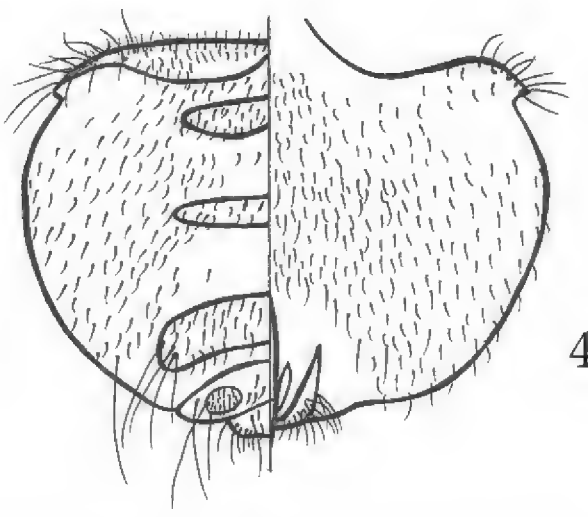

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Figures 39–44. 39 *Icosta minor*, ♀ abdomen, dorsal and ventral view **40** *Icosta ardeae*, ♀ abdomen, dorsal and ventral view **41** *Ornithomya chloropus*, head, ventral view **42** *Ornithomya rupes*, head, ventral view **43** *Ornithomya rupes*, ♀ abdomen, dorsal and ventral view **44** *Ornithomya rupes*, ♂ abdomen, dorsal and ventral view. Abbreviations: tbs – triangle brown spot, tp – tergal plate, vs – vibrissal spines.

1 ♂, from a human, the same, 21.8.2021, 1 ♀, from a human, the same, 3.9.2021, 3 ♀, from a human; Pečovská Nová Ves, 49°07'04.2"N, 21°02'27.3"E, 26.7.2021, 1 ♀, from a human; Drienovec, 48°37'04.4"N, 20°55'29.9"E, 200 m a.s.l., 29.8.2021, 1 ♀, from a human; Prešov env. (near "pri Kríži"), 48°59'57.0"N, 21°13'03.7"E,

300 m a.s.l., 8.9.2021, 2 ♀, from a human; Vinné, 48°48'08.8"N, 21°58'22.7"E, 158 m a.s.l., 12.9.2021, 1 ♀, from a human.

Note. Records from humans and birds are accidental associations and the species do not complete development on this host.

Ornithomya avicularia (Linnaeus, 1758)

Material examined. Gbelce, 47°51'29.4"N, 18°30'17.9"E, 120 m a.s.l., 9.–10.7.2019. 7 ex. from *Panurus biarmicus* (Linnaeus, 1758), the same, 10.7.2019, 1 ex, from *Emberiza schoeniclus* (Linnaeus, 1758); Sabinov Bird Ringing Station, 49°06'02.7"N, 21°04'26.8"E, 370 m a.s.l., 5.7.2021, 1 ♀, from a human; Uzovský Šalgov, around a pond, 49°05'34.8"N, 21°04'00.4"E, 366 m a.s.l., 19.7.2021, 2 ♀, from *H. rustica*, [U62699, U62708], 20.7.2021, 1 ♀, from *H. rustica* [U62754], 23.7.2021, 1 ♀, from *Sturnus vulgaris* Linnaeus, 1758, 24.7.2021, 1 ♀, from *H. rustica*, [U62911], 28.7.2021, 1 ♂, 1 ♀, from a human, 30.7.2021, 3 ♀, from *H. rustica* [U74223, U62999, U74230], 10.8.2021, 1 ♀, from *H. rustica* [U74441].

Note. *Sturnus vulgaris* and *Emberiza schoeniclus* are here recorded as new hosts of *O. avicularia* in Slovakia.

Ornithomya biloba Dufour, 1827

Material examined. Uzovský Šalgov, around a pond, 49°05'34.8"N, 21°04'00.4"E, 366 m a.s.l., 15.7.2021, 1 ♂, 1 ♀, from *R. riparia*, 17.7.2021, 1 ♀, from *H. rustica* [U62640], 20.7.2021, 1 ♂, from *R. riparia* [U62741], 21.7.2021, 1 ♀, from *H. rustica* [U62777, S578974], 11.8.2021, 1 ♂, from *H. rustica*, 2.9.2021, 1 ♀, from *H. rustica* [U81448].

Ornithomya fringillina Curtis, 1836

Material examined. Uzovský Šalgov, around a pond, 49°05'34.8"N, 21°04'00.4"E, 366 m a.s.l., 23.7.2021, 1 ♀, from *H. rustica* [U62870]; Čerený Kláštor, 49°23'16.7"N, 20°23'49.8"E, 22.7.2021, 1 ♀, from *H. rustica* [U87187]; Drienovec, 48°37'04.4"N, 20°55'29.9"E, 200 m a.s.l., 31.8.2021, 1 ♀, from *Curruca curruca* (Linnaeus, 1758) [S564435].

Note. *Hirundo rustica* and *Curruca curruca* are here recorded as new hosts of *O. fringillina* in Slovakia.

Stenepteryx hirundinis (Linnaeus, 1758)

Material examined. Drienovec, 48°37'04.4"N, 20°55'29.9"E, 200 m a.s.l., 30.8.2021, 1 ♂, from *Delichon urbicum*.

Discussion

Updated keys to eleven European hippoboscid genera comprising 31 species are provided. We hope that they will contribute as a tool for determining European specimens of the most fascinating and neglected group of blood-feeding ectoparasites from the family Hippoboscidae (see Bezerra-Santos and Otranto 2020).

The recent checklist of louse flies of the family Hippoboscidae from Slovakia (see Oboňa et al. 2019b) includes 19 species; the present paper increases this list to 20 species. Four new host-parasite associations from Slovakia are also recorded (*O. avicularia* on the reed bunting and European starling, and *O. fringillina* on the barn swallow and the lesser whitethroat; see also Table 2).

Table 2. An overview of recorded host-parasites associations.

Parasites	Hosts
Hippobosca equina	Mammalia: Primates: *Homo sapiens**
Lipoptena cervi	Mammalia: Primates: *Homo sapiens**
Lipoptena fortisetosa	Mammalia: Primates: *Homo sapiens**; Aves: *Parus major**
Ornithomya avicularia	Aves: Passeriformes: *Emberiza schoeniclus*, *Hirundo rustica*, *Panurus biarmicus*, *Sturnus vulgaris*
Ornithomya biloba	Aves: Passeriformes: *Hirundo rustica*, *Riparia riparia*
Ornithomya comosa	Aves: Passeriformes: *Riparia riparia*
Ornithomya fringillina	Aves: Passeriformes: *Curruca curruca*, *Hirundo rustica*
Stenepteryx hirundinis	Aves: Passeriformes: *Delichon urbicum*

* Accidental association, parasite species do not complete development on this host.

Of a total of 20 Slovakian hippoboscid species, 12 are native. The remaining eight species (*Hippobosca longipennis* Fabricius, 1805, *H. variegata* Megerle, 1803, *Icosta minor* (Bigot, 1858), *Olfersia fumipennis* (Sahlberg, 1886), *Ornithoica turdi* (Latreille, 1812), *Ornithophila metallica* (Schiner, 1864), *Pseudolynchia canariensis* (Macquart, 1839), and the newly recorded *Ornithomyia comosa* (Austen, 1930) have been recorded from Slovakia based on very few records due to their hosts being usually occasional visitors (Oboňa et al. 2019b).

According to Nartshuk et al. (2019a), there are two possible explanations for the current distribution of *O. comosa*: *O. comosa* migrates with adult swallows from West Siberia or Kazakhstan to western Russia or *O. comosa* has always or for a long time been present in western Russia, but it has not been previously collected. For the European records of *O. comosa*, migrating swallows cannot bring *O. comosa* from Africa, as *O. comosa* does not occur there, but some *H. rustica* do, spending the winter in Asia, where *O. comosa* occurs. We also assume that records by Doszhanov (1970, 2003) from Kazakhstan and Kyrgyzstan could represent a bridge between the East Asian-Australasian Flyway and the African-Eurasian Flyway (see Boere and Stroud 2006). In this area, parasites can be transferred between hosts from East Asian countries (e.g., India, Nepal, Thailand, Malaya, Japan) to western Siberia, western Russia, and Europe. However, the question is whether *O. comosa* has already adapted to local conditions

and become a native species in Europe or will it continue to be only an occasionally introduced species.

The collection dates by Austen (1930) from India (February–April), King (1969) from Thailand (Bangkok) (ectoparasites collected during "winter"), and Mogi et al. (2002) from Japan (September–December) suggest that *O. comosa* is active mainly in autumn and winter (native populations). However, the findings from Kazakhstan by Doszhanov (1970) are from the period May–October, and the most recent records from the Kaliningrad region (Nartshuk et al. 2019a) correspond to the findings presented in this article, i.e., July and August. Therefore, we believe that the parasite does not have to come from the spring migration but, on the contrary, from the summer/autumn migration (possibly also from the Kaliningrad area). A similar phenomenon is recorded for the non-native species *Ornithoica turdi* (Olivier in Latreille, 1811) (e.g., records from Vienna from August, see Zittra et al. (2020)) transported by hosts from wintering grounds in Africa. The relatively late record after migration from the wintering grounds has two possible explanations. The first is that these parasites are able to live for more than two months (see Chalupský 1980). The second is that it could be a hatched fly, and therefore it may not be a casual traveller from Africa (*O. turdi*) or Asia (*O. comosa*), but that it is already breeding here (as a native species?). This is also indirectly confirmed by the negative findings from the spring migration.

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